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Determination of the Effect of Gully Erosion on Land Use in Nyuwar District, Balanga Local Government Area of Gombe State, Nigeria

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Abstract

Nyuwar District *is typical of heavy black soil developed from basaltic rocks highly susceptible to gully erosion due to its hilly terrain. This research aimed to determine the effect of gully erosion on land use in Nyuwar district. Data were collected from field observation, in-depth interviews, and satellite images. The data were analyzed using descriptive statistics, and GIS methods such as supervised image classification techniques and overlay. Satellite imageries for 2007 and 2020 were used to map the extent and spatial distribution of gullies and other land use and land cover such as built-up areas, farmlands, and vegetation covers. Over the last 13 years, the extent of gully erosion in the study area increased markedly, mostly on cultivated land, while gully density rose from 45.56 ha (0.4556 km^2), representing 2.28% in 2007, to 56.67 ha, representing 2.83% in 2020. Built-up areas increased over the study period, but vegetation cover decreased markedly from 535.39 ha (26.75%) in 2007 to 344.14 ha (17.19%) in 2020. It was concluded that from 2007 to 2020, 14.97 ha of farmlands have become gullied due to erosion. If 1 ha of land produces 15 bags of maize, it follows that 233.91 bags (2.334 tonnes) of maize were lost due to gullies. It is recommended that there should be a routine inspection of the farmlands to see if there are possible chances of future occurrences of gullies to decide possible ways of controlling them. Planting of fast-growing species of plants along the banks of the gullies should be embarked upon to check further loss of farmland to gullies.*

Keywords: Determination, *Gully erosion, land use, Agricultural production,* Nyuwar.

Détermination de l'effet de l'érosion des ravins sur l'utilisation des terres dans le district de Nyuwar, zone de gouvernement local de Balanga, État de Gombe, Nigeria

Résumé

Le district de Nyuwar est typique d'un sol noir et lourd développé à partir de roches basaltiques très sensibles à l'érosion par ravinement en raison de son relief vallonné. Cette recherche visait à déterminer l'effet de l'érosion des ravins sur l'utilisation des terres dans le district de Nyuwar. Les données ont été collectées à partir d'observations sur le terrain, d'entretiens approfondis et d'images satellite. Les données ont été analysées à l'aide de statistiques descriptives et de méthodes SIG telles que des techniques de classification et de superposition d'images supervisées. Les images satellite de 2007 et 2020 ont été utilisées pour cartographier l'étendue et la répartition spatiale des ravins et d'autres utilisations et couvertures terrestres telles que les zones bâties, les terres agricoles et les couvertures végétales. Au cours des 13 dernières années, l'étendue de l'érosion des ravins dans la zone d'étude a nettement augmenté, principalement sur les terres cultivées, tandis que la densité des ravins est passée de 45,56 ha (0,4556 km2), soit 2,28 % en 2007, à 56,67 ha, soit 2,83 % en 2020. Les zones bâties ont augmenté au cours de la période d'étude, mais la couverture végétale a nettement diminué, passant de 535,39 ha (26,75 %) en 2007 à 344,14 ha (17,19 %) en 2020. Il a été conclu que de 2007 à 2020, 14,97 ha de terres agricoles sont devenues. raviné à cause de l'érosion. Si 1 ha de terre produit 15 sacs de maïs, il s'ensuit que 233,91 sacs (2,334 tonnes) de maïs ont été perdus à cause des ravins. Il est recommandé qu'il y ait une inspection de routine des terres agricoles pour voir s'il existe des risques possibles d'apparition future de ravins afin de décider des moyens possibles de les contrôler. La plantation d'espèces végétales à croissance rapide le long des berges des ravins devrait être entreprise pour empêcher une nouvelle perte de terres agricoles au profit des ravins.

Mots clés : *Détermination, Erosion des ravins, utilisation des terres, Production agricole, Nyuwar.*

INTRODUCTION

Land use changes are associated with altering albedo, exacerbating climate change, accelerating soil degradation and erosion, and causing loss of biodiversity (Li *et al.*, 2021). Soil erosion is one of the most prominent environmental impacts associated with land use change and has resulted in extensive loss of productivity and ecosystem services at the global scale (Ercoli *et al.*, 2020). This is a result of the removal of the topsoil by running water, wind, and other agents of denudation. Research and historical evidence have shown that erosion has severe deleterious effects on the productive capacity of soil as well as on ecological well-being (Sunday and Obalum, 2012). Gully erosion, on the other hand, poses worldwide challenges to the sustainability of agriculture, especially in tropical regions as it decreases the rooting depth of plants, soil fertility, and plant-available water reserves (Hemant and Padmini, 2013).

The greatest threat to the environmental settings of North-Eastern and South-Eastern Nigeria is the gradual but constant dissection of the landscape by gully erosion. The incipient stages of gully erosion, namely, sheet-wash and rills, are easily managed by farmers through known soil conservation practices. The gully form of erosion has assumed greater dimensions such that settlements and scarce arable lands are threatened. Therefore, gully erosion problems have become a subject of discussion among soil scientists, geographers, geologists, engineers, and social scientists. Gully erosion is most visible mainly because of the remarkable impression it leaves on the surface of the earth (Jeje, 2005; Mansour and Mohammed, 2011). Estimates suggest that each year, as much as 75 billion tonnes of soil is eroded from the land by water and wind with much of it coming from agricultural lands (Danladi and Ray, 2014; Jonathan, 2018).

Kristine (2018) noted that the rate of soil detachment increases rapidly with rainfall intensity which leads to the rapid development of gullies with deep narrow channels worn by water flow on the dipping surface of the land, have a great impact on the rate of depletion of soil moisture, groundwater and reduced crop productivity (Bationo et al., 2006; Mansour and Muhammad, 2011). World Bank (2013) estimated that soil erosion and gullies in Nigeria affect over 50 million people and account for the loss of

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agricultural products that amounted to US 3,000 million dollars per year and have killed people, destroyed roads, homes, schools, and farmlands, and displaced poor people and increased loss of available land for agricultural purposes and increases labour costs in farm management (Kristine, 2018). David and Mullah (2011) and Danladi and Ray (2014) summarised the effect of soil and gully erosion is that they are removing the cream of the soil.

Gullies of various sizes and lengths are found in many parts of Gombe State, especially where human activities have stripped off vegetation that normally holds and protects the soil. Studies in Gombe State on gully erosion have shown that the different causes of gullies stem from man's activities for various purposes such as intensive cultivation, overgrazing, bush burning, and deforestation (Kristine, 2018). Pimentel (2013) noted that gully erosion is a disastrous environmental problem throughout the world as it is a slow continuous insidious problem to the extent that 1 mm of soil loss in one rainstorm may go unnoticed by farmers. According to Pimentel (2006), 10 million hectares of cropland worldwide are abandoned every year because of gullies and soil erosion. Gully erosion has been identified as one of the problems of both rural and urban landscapes. Poor communities in developing countries are more vulnerable, especially with poor gully erosion control measures for years in Nigeria (Jeje, 2005).

From the foregoing, none of the studies on the effect of gullies on agricultural production looked at the effect of expansion and encroachment of gullies into farmlands and the negative effect on crop production and thus on food insecurity. Furthermore, while land-use/land-cover (LULC) changes affect development, there are not many studies on the impact of gullies on their encroachment into farmlands and their consequence on crop production as observed by Li et *al.* (2021). On this note, it is worth pointing out that there is little research on the relationship between land use and gully erosion on crop production in Nyuwar District, Balanga Local Government Area of Gombe State, Nigeria. Therefore, this research aimed to determine the effect of gully erosion on crop production in the Nyuwar District.

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MATERIALS AND METHODS

Study Area

Nyuwar District is located between Latitudes 9º 46' 0" and 9º 49' 0" N, and Longitudes 11º 44' 0" and 11^0 47' 0" E (figure 1) and covers an area of 19.71 km^2.

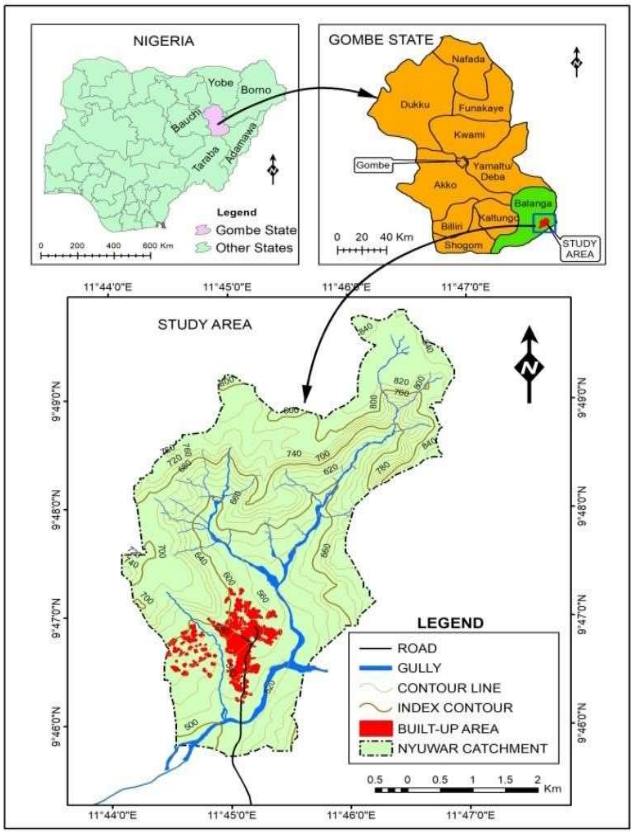

Figure 1: Map of Nyuwar District

Source: Landsat ETM+ of 22/10/2007 and Landsat OLI-TIRS of 23/11/2020

Located in the south-eastern part of Balanga L. G. A. in Gombe State, Nyuwar District shares boundaries with the following neighbouring districts: Jessu and Cham to the south, Sikkim to the north, Kulani in the west, and Adamawa State in the east. According to Koppen's classification of climate, Nyuwar falls within the Aw type of climate (Ikusemoran *et al.,* 2016; Wanah and Mayomi, 2019) which is a tropical wet and dry climate. It follows, therefore, that its climate is

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characterized by two distinct seasons, wet season (April to October) and dry season (November to March). Mean annual rainfall is 863.2 mm (Ikusemoran *et al.,* 2016; Wanah and Mayomi, 2019). During the dry season, the temperature is low, 24^{o} C from December to February, and high about 34 ^{o} C from March to October. Relative humidity levels are quite high, reaching an average of 95% from July to September, during which more rainy days are experienced (Ikusemoran *et al.,* 2016).

The geology of the area is within the Upper Cretaceous terrestrial sedimentation with much of the rocks being those of Bima Sandstone. There are igneous rocks that account for the hilly terrain of the area. It suffices to say that the hydrological system of the area is governed by the terrain giving rise to many surface water sources. The topography of Nyuwar District is influenced by its geology with several hills of basaltic rocks, which are evidence that the area must have experienced volcanic activity. The hills, referred to as Lunguda Hills, have their highest points, reaching elevations of 700 meters above mean sea level (Ikusemoran et al., 2016; Wanah and Mayomi, 2019). The highland slopes steeply to a level of 475 meters near Putoki village to the north and Yolde in the south. The soil of Nyuwar is dark heavy clay soil (Chernozem) that develops cracks in the dry season and is characteristically fertile and good for agricultural production. With regards to its ecological location, Nyuwar falls within the Sudan Savannah vegetation zone and consists of open grassland dotted with stunted woody trees with hardbacks adapted for reducing loss of water through evaporation. Tree species included baobab, tamarind, and neem. Shrubs and herbs of various species are common (Mbaya, 2012). Nyuwar's dominant economic activities are primary economic activities: farming and rearing of animals. Crops cultivated include guinea corn, maize, millet, beans, rice, and cash crops such as soya beans. Animals reared included goats, sheep, and cattle.

Data collection

A reconnaissance survey was conducted by the researchers to gain familiarity with the study area. This allowed for the identification and assessment of gullies, including their spatial distribution, width, and depth, with a particular focus on farmland areas. Data for the research were gathered from both primary and secondary sources. Primary data collection involved surveys and ground-truthing. Focal group discussions were conducted by interviewing two groups of men aged 50 years and above who were involved in farming in the area and were asked about crop production and the problem of gully erosion in Nyuwar to gather valuable information and insights into the impact of gully erosion on crop production and the expansion of the gullies. Ground-truthing involved physically visiting the study area to verify and validate information obtained from the interviews using the same information and relating it with satellite imageries of gully development in the area. Secondary data were obtained from various sources, including satellite images of the study area, such as Landsat ETM+ of 22/10/2007 and Landsat OLI-TIRS of 23/11/2020 (Table 1), both with a spatial resolution of 30 meters and a scene along path 186 row 53, downloaded and analysed using ArcGIS software.

Table 1. Characteristics of the Landsat images of the study area for 2007 and 2000.

Type of Satellite	Date of acquisition	Row/Path	Spatial Resolution (m)	Source
Landsat 7 ETM+	22/10/2007	p183/r052	30m	USGS
Landsat 08 OLI - TIRS	23/11/2020	p183/r052	30m	USGS

Data analysis

Supervised image classification and descriptive analysis were used to analyse and interpret the collected data. This analysis facilitated a comprehensive understanding of the information gathered from surveys, focus group discussions, and ground truthing. Furthermore, ArcGIS software was utilized to analyse land use/land cover changes using supervised image classification techniques (Maximum Likelihood Classification), enabling the assessment of changes in land cover patterns, specifically related to the effects of gully erosion on crop production. The analysed data were presented in the form of tables and maps to enhance clarity and facilitate comprehension. These visual representations provided a comprehensive overview of the research findings and aided in the interpretation of the results.

The accuracy assessment of the 2007 LULC classification in Nyuwar District reveals a high overall accuracy of 87.41%, indicating strong agreement between classified and reference data (Table 2). User accuracy was highest for vegetation (94.59%) and gullies (91.67%), reflecting reliable classification in these categories. However, built-up areas (78.38%) and cropland/farmland (84.85%) had lower user accuracy, indicating some misclassifications. The producer's accuracy varied, with gullies achieving 100% accuracy, showing all actual gully samples were correctly identified, while cropland/farmland had the lowest producer's accuracy at 75.68%. These variations suggest that while the classification process was generally robust, certain land types, particularly built-up areas, and cropland/farmland, experienced classification challenges likely due to overlapping spectral signatures or mixed land-use scenarios.

Table 2: Accuracy Assessment of Year 2007 LULC

Classified	Built up	Cropland/ farmland	Gully	Vegetation	**Total**	**Correct sampled**	**User's Accuracy**
Built up	29	5	0	3	37	29	78.38
Cropland/ farmland	4	28	0	1	33	28	84.85
Gully	0	2	33	1	36	33	91.67
vegetation	0	2	0	35	37	35	94.59
Total	33	37	33	40	143	125	87.41
Correct samples	29	28	33	35	125		
Producers Accuracy	87.88	75.68	100.00	87.50	87.41		
Overall Accuracy	87.41						

For 2020, the overall accuracy slightly decreased to 85.71%, maintaining high reliability but showing some increased complexity in land classification over time (Table 3). User's accuracy remained high for gullies (92.31%) and vegetation (88.89%), but was lower for built-up areas (77.50%) and cropland/farmland (86.67%). The producer's accuracy was again lowest for built up areas (77.50%), indicating challenges in accurately classifying urban expansion as possibly blending with cropland/farmland. The slight decrease in overall accuracy from 2007 to 2020 reflects the dynamic changes in land use, suggesting a need for refined classification techniques and better ground-truth data. These assessments emphasize the necessity for improving classification methods to enhance the accuracy of critical land use categories, which is vital for effective land management and sustainable development.

Table 3: Accuracy Assessment of Year 2020 LULC

Classified	Built-up	Cropland/ farmland	Gully	Vegetation	**Total**	**Correct sampled**	**User's Accuracy**
Built up	31	5	1	3	40	31	77.50
Cropland/ farmland	5	39	0	1	45	39	86.67
Gully	2	0	24	0	26	24	92.31
vegetation	2	1	1	32	36	32	88.89
Total	40	45	26	36	147	126	85.71
Correct samples	31	39	24	32	126		
Producers Accuracy	77.50	86.67	92.31	88.89	85.71		
Overall Accuracy	85.71						

RESULTS AND DISCUSSION

Land-use/land-cover (LULC) analysis of Nyuwar District in 2007 and 2020

The statistics of the extent of LULC changes within the study area from 2007 to 2020 are shown in Table 4.

Table 4: LULC Statistics showing Gully sites in Nyuwar District in 2007 and 2020

LULC Class	**2007**		**2020**		Changes 2007 - 2020		Annual Rate (%)
	Area (ha)	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	
Built up	75.15	3.75	99.49	4.97	24.34	24.46	1.75
Farmlands	1345.70	67.22	1501.50	75.01	155.80	10.38	0.74
Gully	45.56	2.28	56.67	2.83	11.12	19.62	1.40
Vegetation	535.39	26.75	344.14	17.19	-191.25	-55.57	-3.97
Total	2001.80	100.00	2001.80	100.00	0.01	0.00	0.00

In 2007, results show that the district covered an area of 2001.80 ha out of which gullies covered 45.56 ha, built-up area covered 75.15 ha, and farmland covered

1345.70 ha. Vegetated fields covered 535.39 ha. Therefore, the total land area covered by gullies as of 13 years ago represents 2.28 % of the total land area of the district. Generally, the table indicates that much of the land was designated as Farmland (67.22%), followed by Vegetation (26.75%), Built-up area (3.75 %), and Gullies (2.28 %).

Analysis of LULC classes in Nyuwar in 2020 shows that 56.67 ha was occupied by gullies which represented 2.83% of the total LULC classes, while the built-up area covered 99.49 ha of land, 1501.50 ha was farmland, and 344.14 ha was covered by vegetation. The development of gullies in the district from 2007 to 2020 shows an increase in the land area occupied by gullies from 2.28% to 2.83% giving a variation of 0.55%. Other forms of land use might have contributed to the development of gullies. This percentage (0.55%) represents 19.62 ha of other land uses that were converted to gullies, implying that the land that was hitherto cultivated for crop production/vegetation has been lost to gullies. This is in line with Jonathan's (2018) estimate that each year, as much as 75 billion tonnes of soil is eroded from the land by water and wind, with much of it coming from agricultural lands. The loss of land has some negative consequences on crop production and thus on food security. In related research in South Africa, Tandzi and Mutengwa (2020) estimated that maize yields 936 kg/ha which is about 10 bags of maize (1 bag of maize is 100 kg). Since 1 ha produces 10 bags, it follows that the gullies deprived the district of the production of 155.74 bags of maize (1.56 tonnes) in 2020. Liu and Yan (2009) reported some 250,000 gullies in China accounting for a reduction in the area of cultivated land and the loss of grain productivity. Besides maize, crops such as beans and cucumber which were usually intercropped with maize also suffered some losses in the quantities that might have been produced. The decrease of 155.74 bags of maize and that of some inter-planted crops on the lost land present the degree of the effect of reduced agricultural productivity which spells doom for food security. The annual rate of change in Land Use/Land Cover (LULC) in Nyuwar District from 2007 to 2020 reveals significant shifts that impact environmental sustainability and land management. Built-up areas expanded at an annual rate of 1.75%, reflecting urbanization and infrastructural development. Farmlands increased by

0.74% annually, indicating agricultural intensification driven by the need to meet growing food demands. However, this agricultural expansion must be carefully managed to avoid further environmental degradation. The most concerning trend is the increase in gully areas, which grew at 1.40% per year, highlighting severe soil erosion issues that reduce arable land and affect agricultural productivity. This underscores the need for effective soil conservation and sustainable land management practices.

Conversely, vegetated areas saw a significant annual decline of 3.97%, indicating extensive deforestation and land clearing for other uses. The loss of vegetation exacerbates soil erosion, reduces biodiversity, and disrupts local ecosystems, emphasizing the critical need for reforestation and conservation initiatives. These trends call for integrated land-use planning and management strategies that balance development with environmental sustainability. Efforts such as promoting sustainable agricultural practices, reforestation programs, and establishing protected areas are essential to mitigate these adverse changes and ensure the long-term health and productivity of the land in Nyuwar District.

Figure 2 shows the LULC map and the extent of gully erosion sites in 2007 and 2020.

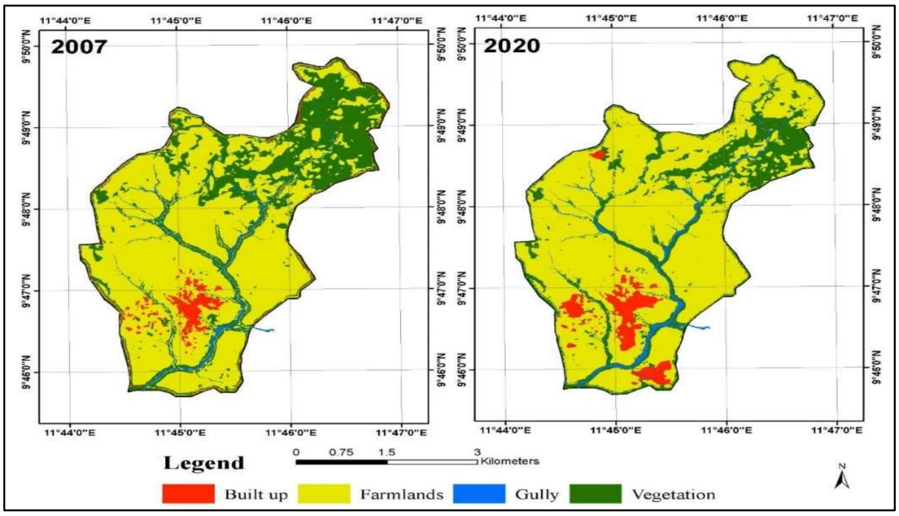

Figure 2: LULC Nyuwar District in 2007 and 2020

Source: Landsat ETM+ of 22/10/2007; OLI-TIRS of 23/11/2020; Field survey 2020

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This confirms the World Bank (2013) report which estimated that soil erosion in Nigeria accounted for the loss of agricultural products amounting to US 3,000 million dollars per year. The cause of gullies and thus the reduction of farmland is attributed to farming on sloppy and marginal land, continued felling, and clearance of vegetation, which exposed the soil to sheet and rill erosion development which eventually became gullies.

Encroachment

Analysis of LULC in the district shows that 14.97 ha of farmland was converted into gullies from 2007 to 2020. The loss is a severe geomorphic degradation of agricultural farmland that directly affects crop production. This is in agreement with Mansour and Mohammed (2011); Pimentel (2013) and Kristine (2018) who reported that erosion reduces crop yield through the destruction of soil's physical properties as well as the reduction in plant nutrients. The LULC analysis also shows that very few residential dwellings were lost to gullies (Table 5). The shaded values shown diagonally represent what was omitted from a certain class of 2007 to different classes of 2020. For example, nothing changed from gully to built-up area under the gully column from 2007 to 2020. It also shows that 32.44 ha of land remained gullies, while only 0.82 ha was converted from gully to vegetated land cover. Similarly, the values of 2020 are read along the row across the columns. The values represent what was committed from different classes of 2007 to a certain class of 2020. For example, gullies gained an insignificant value of 0.01 ha from built-up areas between 2007 and 2020. Li *et al.* (2021) also reported an increase in cultivated land and a reduction in forested land which contributed to intensification of gully erosion in Kedong over the past 50 years. There is also a conversion of 14.97 ha that was formally used as farmland to gullies. In addition, a land equivalent to 9.18 ha was transformed into gullies from vegetation over 13 years (2007 to 2020) (Table 5 and Figure 3).

Table 5: LULC Encroachment/Conversion Statistics (ha)

	Built up	**Farmlands**	**Gully**	**Vegetation**	**2007 LULC**
Built up	48.02	13.13	0.09	13.91	75.15
Farmlands	48.19	1229.01	14.97	52.77	1344.94
Gully	0.00	12.30	32.44	0.82	45.56
Vegetation	3.28	247.06	9.18	276.63	536.15
2020 LULC	99.49	1501.50	56.67	344.14	2001.80

Source: Landsat ETM+ of 22/10/2007; OLI-TIRS of 23/11/2020; Field survey 2020

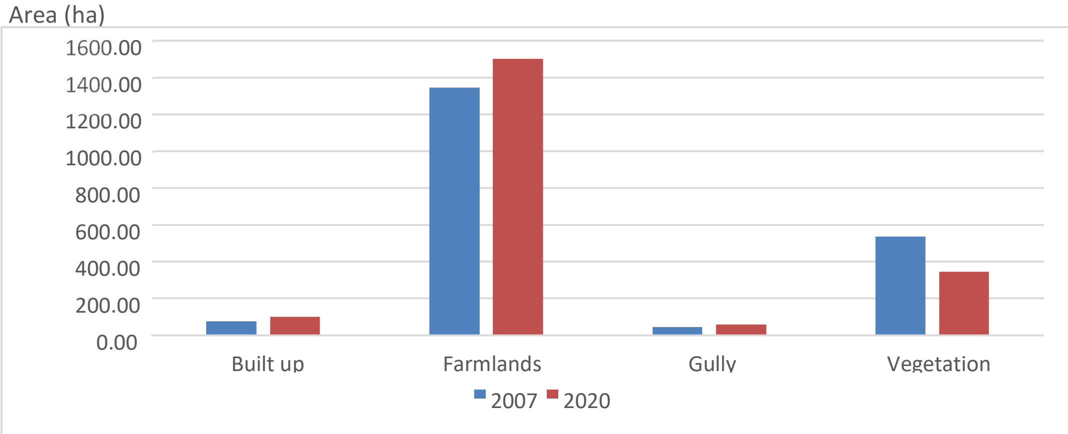

Figure 3: Land use changes from 2007 to 2020

The spatial distribution of erosion encroachments over 13 years in the River Nyuwar catchment is depicted in Figure 4. From the figure, it suggests that poor farmland management practices might have contributed to the ongoing erosion in the area. This encroachment can be attributed to a decrease in infiltration capacity leading to increased runoff. Factors such as deforestation and poor farmland management practices in the upper sections of the catchment contributed to the erosion processes. Overall, the spatial distribution of erosion encroachments in the River Nyuwar catchment highlights the importance of riparian vegetation in mitigating erosion, the impact of land cover conversion on erosion progression, and the influence of farmland management practices on erosion rates. These observations emphasize the need for effective land management strategies and sustainable farming practices to mitigate erosion and preserve agricultural productivity in the area.

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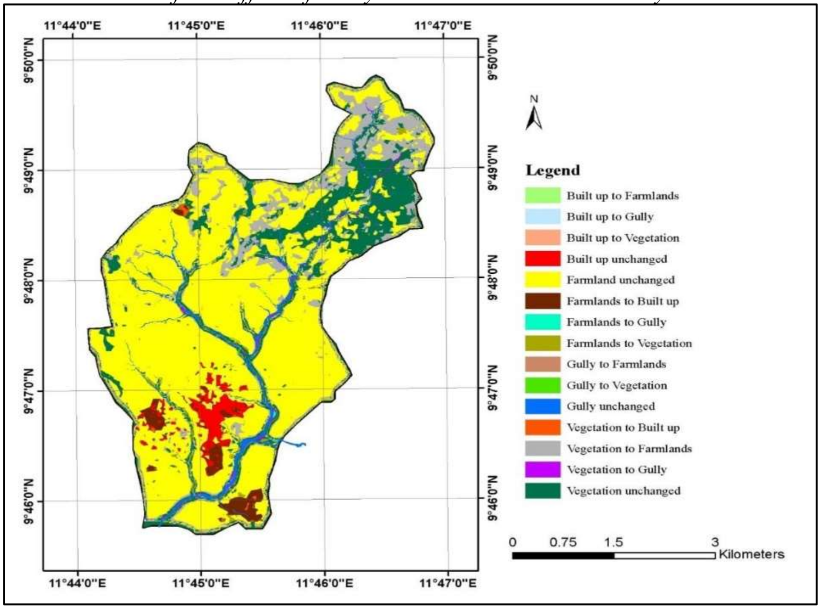

Figure 4: LULC Encroachment changes from 2007 to 2020

Source: Landsat ETM+ of 22/10/2007 and Landsat OLI-TIRS of 23/11/2020

Effect of gully erosion on crop production in Nyuwar district

Gully development in Nyuwar District is a widespread occurrence that has resulted in significant changes in width, length, and number of gullies, which reduced the available land for crop production, which has serious implications for food production. Soil plays a vital role in supporting plants and providing water and nutrients. When erosion washes away the soil, it exposes crop roots to surface runoff leading to surface wash and rills that can eventually evolve into gullies (Table 5 and Plate 1 a & b). Soil erosion is commonly associated with decreased soil fertility leading to yield reduction. The area occupied by gullies increased from 40.66 ha in 2007 to 56.26 ha in 2020. This is a significant change and it indicates that a substantial portion of the land has been converted into gullies resulting in reduced agricultural land. In 2007, gullies covered 2.06% of the total land area in the district which expanded to 2.85% in 2020 as illustrated in the LULC map in Figure 4. This indicates that gullies in 2020 were wider, longer, and more numerous than those in 2007. These findings align with the findings of Xiong *et al.* (2019) who reported that erosion leads to decreased agricultural potential. The assertion corroborates Liu and Yan (2009) who reported that 250,000 gullies accounted for a loss of grain productivity in China.

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Gully erosion is the most prevalent and has both on-site and significant off-site ecological effects (Dotterweich, *et al.*, 2012). Vegetation plays a crucial role in maintaining compacted soil through its root system, reducing surface wash, and providing resistance to erosion. However, when vegetation is cleared for farmland and settlements, the soil becomes exposed and susceptible to removal by running water, resulting in gully development and a reduction in available agricultural land. In the study area, vegetation cover decreased from 24.86% in 2007 to 14.61% in 2020. This decrease can be attributed to deforestation for settlement, farmland, fuel wood, and timber as indicated by the increase in built-up areas over the study period. These findings highlight the detrimental impact of gully erosion on agricultural production in Nyuwar District. The loss of fertile soil and reduced land area for farming pose significant challenges to food security. Efforts should be directed towards sustainable land management practices including afforestation and urban planning strategies to mitigate erosion, preserve soil fertility, and safeguard agricultural productivity.

a b

Plate 1 a and b: Gully Erosion Consuming Farmlands in Gombe

Source: Authors field work, October 2023

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Focus Group Discussion on the Effect of Gully Erosion on crop production in Nyuwar district

From the focus group discussion with community elders, it was gathered that erosion has become a major threat to food production and not only that, it has destroyed many houses which compelled people to relocate to houses far away from erosion-prone sites. Farms were reported flooded in 2018, and much of the crops planted were washed by water. Farmers were also reported to have abandoned parts of their farmlands as the fertile soils were washed away exposing rocks and stones in the sub-soil such that the gullies extended into the arable portions of the land. As a result of the encroachment of gullies into farmlands, farmers have been forced to cut off and abandon portions of their farms that were close to gullies. The effect is a further reduction in the sizes of farmland which leads to a decrease in crop production and thus to food insecurity. Many years ago, the respondents explained, there were few narrow gullies but have increased in size and depth. For instance, the streams that flow from Yakilahi Hill were less than 5 meters wide but are now more than 20 meters wide. They explained further that on either side of the gullies were farmlands that were encroached into thereby reducing the sizes of farmlands. Also, there have been reports on the reduction in crop yield due to gully erosion. Farmers reported a reduction in soya beans from the normal 7-10 bags/ha before gully establishment to only 3-5 bags in 2017.

CONCLUSION

This study focused on the effect of gully erosion on crop production. The findings of the research demonstrate the severe effect of gully erosion on farmland in Nyuwar district which leads to the loss of cultivable land and a decrease in crop production. Anthropogenic activities such as clearing vegetation for farming, contributed to further development of gullies, exacerbating the problem and reducing agricultural productivity. Observations from satellite imageries show that between 2007 and 2020, 15.59 ha of land was lost to gullies resulting in a significant reduction in maize production by 2.34 tonnes. If this trend continues unchecked, the district will face even further reductions in food production which lead to food insecurity within the community. To address the problem of gully erosion in the district, it is recommended that farmers be educated on the adverse effects of farming on sloping land and on the importance of preserving vegetation cover. Farmers should be encouraged to adopt proper farming practices that minimize soil erosion. Regular inspections of farmland should be carried out to detect and address potential gully development at an early stage. It is also recommended that stakeholders, including government, Non-Governmental Organizations (NGOs), and individuals collaborate to combat the problem of gully erosion in the district. This collaborative effort should involve the implementation of effective erosion control measures and the restoration of vegetation along gully banks to prevent further loss of farmland. By raising awareness, promoting sustainable farming practices, and implementing erosion control measures, Nyuwar District can mitigate the effects of gully erosion, protect agricultural land, and ensure food security for the community.

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